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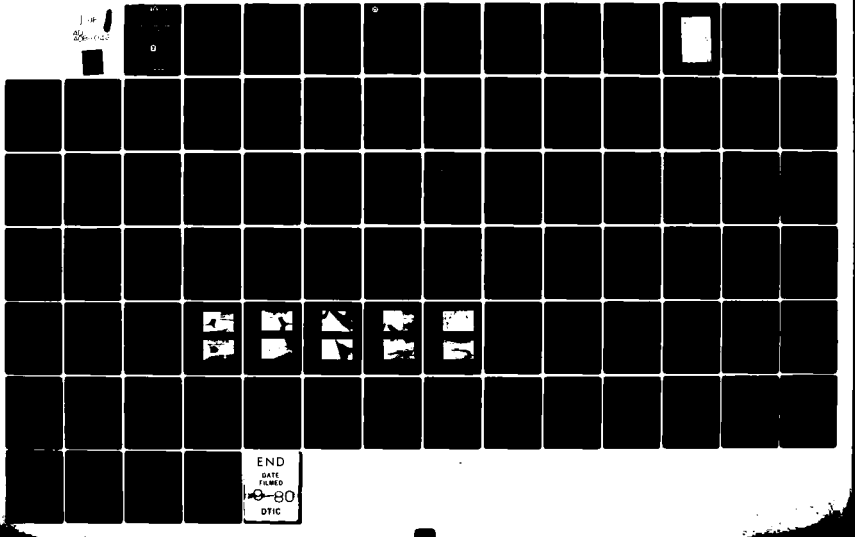

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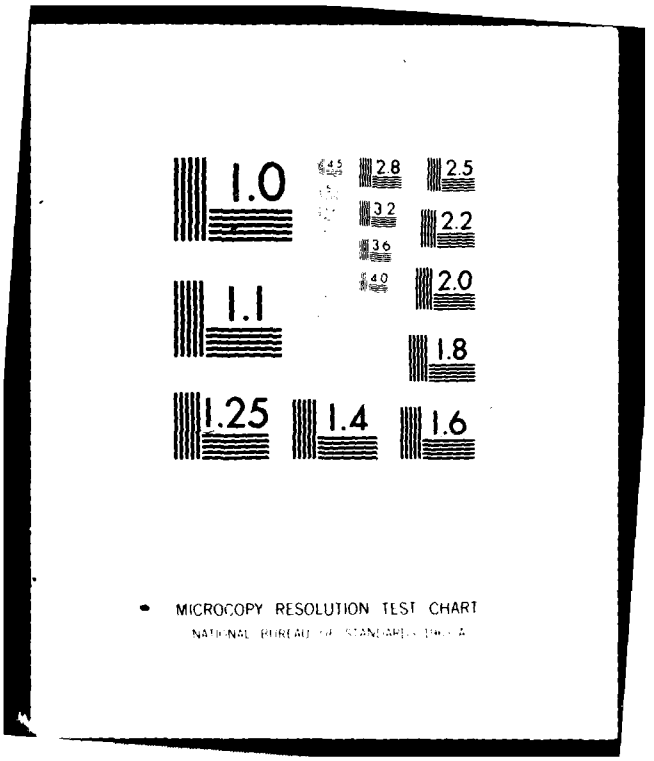
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PASSAIC RIVER BASIN
PECKMAN RIVER, ESSEX COUNTY
NEW JERSEY

VERONA LAKE DAM
NJ 00386

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

FEBRUARY 1980

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NJ00386	2. GOVT ACCESSION NO.: AD-A088043
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): Phase I Inspection Report National Dam Safety Program Verona Lake Dam NJ00386 Essex County, New Jersey	5. TYPE OF REPORT & PERIOD COVERED: FINAL
	6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): RICHARD McDERMOTT	8. CONTRACT OR GRANT NUMBER(s): DACW61-79-C-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Storch Engineering 220 Ridgedale Ave. Florham Park, N.J. 07932	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11. CONTROLLING OFFICE NAME AND ADDRESS: NJ Department of Environmental Protection Division of Water Resources P.O. Box CN029 Trenton, NJ 08625	12. REPORT DATE: Feb. 1980 13. NUMBER OF PAGES: 76
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office): U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, PA 19106	15. SECURITY CLASS. (of this report): Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams	National Dam Safety Program
Embankments	Verona Lake Dam, New Jersey
Visual Inspection	Spillways
Structural Analysis	Seepage

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

11 AUG 1980

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Verona Lake Dam in Essex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Verona Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 33 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

b. With the lake drawn down, the masonry spillway should be thoroughly inspected by a professional consultant engaged by the owner within six months from the date of approval of this report. Based on the inspection, together with any necessary subsoil, seepage and structural investigations, the need for remedial measures should be determined and the measures implemented.

c. The owner should develop an emergency action plan and downstream warning system within six months from the date of approval of this report.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

NAPEN-N
Honorable Brendan T. Byrne

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Minish of the Eleventh District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

VERONA LAKE DAM (NJ00386)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 14 November 1979 by Storch Engineers under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Verona Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate because a flow equivalent to 33 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Within three months of the consultant's findings, remedial measures to ensure spillway adequacy should be initiated.

b. With the lake drawn down, the masonry spillway should be thoroughly inspected by a professional consultant engaged by the owner within six months from the date of approval of this report. Based on the inspection, together with any necessary subsoil, seepage and structural investigations, the need for remedial measures should be determined and the measures implemented.

c. The owner should develop an emergency action plan and downstream warning system within six months from the date of approval of this report.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 24 Jul '80

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Verona Lake Dam, NJ00386
State Located:	New Jersey
County Located:	Essex
Drainage Basin:	Passaic River
Stream:	Peckman River
Date of Inspection:	November 14, 1979

Assessment of General Condition of Dam

Based on visual inspection, past operational performance and Phase I engineering analyses, Verona Lake Dam is assessed as being in fair overall condition.

Hydraulic and hydrologic analyses indicate that the spillway is inadequate. Discharge capacity of the spillway is not sufficient to pass the designated spillway design flood (SDF) without an overtopping of the dam. (The SDF for Verona Lake Dam is equal to one-half the probable maximum flood.) The spillway is capable of passing approximately 16 percent of the probable maximum flood or 32 percent of the SDF. Therefore, the owner should engage a professional engineer experienced in the design and construction of dams in the near future to perform accurate hydraulic and hydrologic analyses relating to the spillway capacity. Based on the findings of the analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

No significant signs of distress were observed in the embankment. However, evidence of leaching was observed in the lower portion of the spillway. Therefore, the spillway should be inspected with the lake drawn down by a professional engineer experienced in the design and construction of dams. Based on the inspection, together with any necessary subsoil, seepage and structural investigations, the need for remedial measures should be determined and the measures implemented.

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to insure the safety of the dam.

(9) Final rept. (11) [illegible] (12) [illegible]

(15) DACW61-79-C-0011

Richard J. McDermott, P.E.

John E. Gribbin, P.E.

(6) National Dam Safety Program. Verona Lake Dam (NJ00386), Passaic River Basin, Peckman River, Essex County, New Jersey. Phase I Inspection Report.

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OVERVIEW - VERONA LAKE DAM

29 NOVEMBER 1979

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TABLE OF CONTENTS (cont.)

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 30214. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that the unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

VERONA LAKE DAM, I.D. NJ00386

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) in cooperation with the Philadelphia District of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the State of New Jersey. Storch Engineers has been retained by the NJDEP to inspect and report on a selected group of these dams. The NJDEP is under agreement with the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Verona Lake Dam was made on November 14, 1979. The purpose of the inspection was to make a general assessment of the structural integrity and operational adequacy of the dam structure and its appurtenances.

1.2 Description of Project

a. Description of Dam and Appurtenances

Verona Lake Dam consists of a masonry overflow spillway with earth embankment abutting each end. The masonry overflow portion consists of a sloped downstream face and a concrete crest. At the junction between spillway and earth embankments, stone masonry training walls extend upstream and downstream from the spillway.

The spillway is 124 feet in length while the overall length of the dam, which is oriented approximately east/west is 438 feet. The elevation of the spillway crest is 343.9 (N.G.V.D.) while that of the dam crest is 345.9. The hydraulic height of the dam is 13 feet and structural height is estimated to be 16.3 feet. The outlet works for this dam consists of a 24-inch cast iron pipe located at the west side of the spillway. This outlet is controlled by a gate valve located in a manhole adjacent to the spillway.

b. Location

Verona Lake Dam is located in Verona Park, Borough of Verona, Essex County, New Jersey. Constructed across Peckman River, the dam impounds Verona Lake which is located within the park. The dam is readily accessible by park roads.

c. Size and Hazard Classification

Size and Hazard Classification criteria presented in "Recommended Guidelines for Safety Inspection of Dams," published by the U.S. Army Corps of Engineers are as follows:

SIZE CLASSIFICATION

	Impoundment	
	Storage (Ac-ft)	Height (Ft.)
Small	< 1000 and ≥ 50	< 40 and ≥ 25
Intermediate	≥ 1000 and $< 50,000$	≥ 40 and < 100
Large	$\geq 50,000$	≥ 100

HAZARD POTENTIAL CLASSIFICATION

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (no permanent structures for human habitation	Minimal (Undeveloped to to occasional structures or agriculture)
Significant	Few (No urban developments and no more than a small number of inhabitable structures	Appreciable (Notable agriculture, industry or structures)
High	More than a small number	Excessive (Extensive community, industry or agriculture)

The following data relating to size and downstream hazard for Verona Lake Dam have been obtained for this Phase I assessment:

Storage: 96 Acre-feet

Height: 13 feet

Potential Loss of Life:

Heavily used road (Bloomfield Avenue) and urban development within downstream flood plain. Failure of dam could cause loss of life.

Potential Economic Loss:

Dam failure could cause heavy damage to the Bloomfield Avenue bridge as well as downstream development.

Therefore, Verona Lake Dam is classified as "Small" size and "High" hazard potential.

d. Ownership

Verona Lake Dam is owned and operated by Essex County Parks Division.

e. Purpose of Dam

The purpose of the dam is the impoundment of a lake used for recreation.

f. Design and Construction History

Verona Lake Dam reportedly was originally constructed in 1903 with a clay berm on the upstream side and a masonry wall on the downstream side. In 1928 a new masonry face with footing was added to the downstream side and a new concrete crest added to the entire length of the masonry overflow portion of the dam. Plans for the 1928 improvement are available in NJDEP files.

g. Normal Operational Procedures

The dam and appurtenances are operated and maintained by Essex County Parks Division. There is no fixed schedule for maintenance; repairs are made as the need arises.

1.3 Pertinent Data

a. Drainage Area	1.9 square miles
b. Discharge at Damsite	
Maximum flood at damsite	Unknown
Outlet works at pool elevation	16 c.f.s.
Spillway capacity at top of dam	1076 c.f.s.
c. Elevation (Feet above MSL)	
Top of dam	345.9
Maximum pool-design surcharge	347.2
Recreation pool	343.9
Spillway crest	343.9
Stream bed at centerline of dam	332.9
Maximum tailwater	339.0 (Estimated)

d. Reservoir

Length of maximum pool	2,500 feet (Estimated)
Length of recreation pool	2,400 feet (Scaled)

e. Storage (Acre-feet)

Recreation pool	60 acre-feet
Design surcharge	121 acre-feet
Top of dam	95 acre-feet

f. Reservoir Surface (Acres)

Top of dam	19.1 acres (Estimated)
Maximum pool	20.6 acres (Estimated)
Recreation pool	16.5 acres
Spillway crest	16.5 acres

g. Dam

Type		Masonry/Earthfill
Length		438 feet
Height		13 feet
Sideslopes		
Embankments	-Upstream	2 horiz. to 1 vert.
	-Downstream	12 horiz. to 1 vert.
Masonry	-Upstream	2 horiz. to 1 vert.
	-Downstream	1 horiz. to 2 vert.
Zoning		Unknown
Impervious core		Unknown
Cutoff		Unknown
Grout curtain		Unknown

h. Diversion and Regulating Tunnel — N.A.

i. Spillway

Type	Uncontrolled concrete weir
Length of weir	124 feet
Crest elevation	343.9
Gates	N.A.
Approach channel	N.A.
Discharge channel	Stone paved channel

j. Regulating Outlet

24-inch gated CIP outlet

SECTION 2: ENGINEERING DATA

2.1 Design

Plans of improvements completed in 1928 by Essex County Park Commission are available in the NJDEP files. Hydraulic calculations prepared by the State of New Jersey in 1934 indicated that the spillway capacity was adequate for the applicable design flood. (The choice of design flood was unclear.) No design drawings relating to the original construction in 1903 are available.

2.2 Construction

Inspection reports indicating that the 1928 improvements were completed satisfactorily are available in the NJDEP files. No drawings or inspection reports relating to the original construction are available.

2.3 Operation

No records of operation and maintenance of the dam subsequent to construction are available. An inspection report written in 1968 for the State of New Jersey indicated that the dam structure was in stable condition.

2.4 Evaluation

a. Availability

Available engineering information is limited to that which is on file at the NJDEP. This file contains information relating to the reconstruction work done in 1928. No information pertaining to the original construction is available.

b. Adequacy

Available engineering data pertaining to Verona Lake Dam provided limited assistance in performing this Phase I evaluation. A list of absent information is included in Paragraph 7.1.b.

c. Validity

In general, information that could be verified was found to be valid within a reasonable allowance for error. However, one minor discrepancy was noted: whereas the plans and calculations indicated a two staged spillway with a lower section, or notch, in the center, field inspection revealed a spillway crest with a depression in the center.

SECTION 3: VISUAL INSPECTION

3.1 *Findings*

a. General

The inspection of Verona Lake Dam took place on November 14, 1979 by members of the staff of Storch Engineers. A copy of the visual inspection check list is contained in Appendix 1. The following procedures were employed for the inspection:

1) The embankment of the dam, appurtenant structures and adjacent areas were examined.
2) The embankment and appurtenant structures were measured and key elevations determined by a surveyor's level.
3) The embankment and appurtenant structures and adjacent areas were photographed.
4) Depths of water were measured at various locations in the lake.

b. Spillway

The masonry overflow portion of the dam comprises the spillway. The crest of the spillway is formed with a depressed section at the center where most dry weather overflow occurs. Several areas of leaching were observed on the downstream face near the toe of the spillway. Some leachate did not appear to be composed of soil, but appeared to contain deteriorated mortar. Evidence of leakage was observed

discharging immediately below the concrete cap which forms the spillway crest. The stone masonry training walls appeared to be in good condition with small amounts of patching near the top.

The outlet works control mechanism and the manhole housing it appeared to be in satisfactory condition. The discharge end of the 24-inch cast iron outlet pipe appeared to be clear and in satisfactory condition.

c. Embankments

Both embankments are grass covered with paved walkways on their crests. The upstream face of the west embankment consists of a continuation of the west training wall of the spillway. There are no visible signs of erosion or other distress in the embankments.

d. Reservoir Area

Verona Lake has a maximum length of about 2400 feet with widths varying from 160 to 480 feet. The entire shore line and most of the watershed constitutes a County park.

e. Downstream Channel

Discharge from Verona Lake Dam enters Peckman River by way of a rectangular channel paved with cobble stones. Two pedestrian bridges span the channel about 40 feet and 140 feet downstream from the spillway. Further downstream, the channel passes under a concrete road bridge into a natural channel through an urban area of Verona. Buildings near the channel are estimated to be 7 to 10 feet above the stream bed.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The water level in Verona Lake is naturally controlled by overflow over the spillway. Reportedly the lake is not lowered for any purpose. Although the gate was not opened at the time of inspection, the operating mechanism appeared to be in satisfactory condition.

4.2 Maintenance of the Dam

There is no program of regular inspection and maintenance of the dam and appurtenant structures. Maintenance is performed by the staff of Essex County Park Division on an "as needed" basis.

4.3 Maintenance of Operating Facilities

Maintenance of operating facilities is performed on an "as needed" basis.

4.4 Description of Warning System

Reportedly, no formal warning system is in use at the present time. However, surveillance is performed by the Essex County Division of Parks.

4.5 Evaluation of Operational Adequacy

The operation of the dam has been satisfactory in that no overtopping has been recorded.

Maintenance documentation is poor but the overall condition of the dam indicates that normal maintenance has been generally satisfactory.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The quantity of storm water runoff that the spillway should be able to pass without an overtopping of the dam is based on the size and hazard classification of the dam. This runoff, called the Spillway Design Flood (SDF), is described in terms of frequency or probable maximum flood (PMF) depending on the extent of the dam's size and potential hazard. According to the "Recommended Guidelines for Safety Inspection of Dams," published by the U.S. Army Corps of Engineers, the SDF for Verona Lake Dam falls in a range of 1/2 PMF to PMF. In this case the low end of the range, 1/2 PMF, is chosen since the factors used to select size classification are on the low side of their respective ranges.

The SDF hydrograph for Verona Lake was computed by use of the HEC-1-DB computer program using the SCS Method. Hydrologic computations and computer output are contained in Appendix 4. The calculated SDF peak inflow for Verona Lake Dam is 3577 c.f.s.

Discharge capacity for the spillway was computed by considering free discharge over the masonry portion of the dam. Hydraulic computations are contained in Appendix 4.

The SDF was routed through the dam by the use of the HEC-1-DB computer program using the modified Puls method. In routing the SDF, it was found that the dam would be overtopped to a height of 1.3 feet. A dam breach would probably not significantly increase the hazard potential for

loss of life downstream due to dam failure from overtopping over that which exists without failure. Accordingly, the subject spillway is assessed as being inadequate in accordance with criteria developed by the U.S. Army Corps of Engineers.

b. Experience Data

No record has indicated that the dam has ever been overtopped.

c. Visual observation

No evidence was found at the time of inspection that would indicate that the dam had been overtopped.

d. Overtopping Potential

As indicated in paragraph 5.1.a, a storm of magnitude equivalent to the SDF would cause overtopping of the dam by a height of 1.3 above the top of the dam. The spillway is capable of passing approximately 16% of the PMF or 32% of the SDF with lake level equal to the top of the dam (elev. 345.9).

e. Drawdown Time

Drawdown of the lake is accomplished by opening the gate in the 24-inch cast iron outlet pipe. Total time for drawdown is estimated to be 3.7 days. (See Appendix 4)

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The embankment appeared, at the time of inspection, to be outwardly stable. No significant indications of possible distress were observed. Approximately 2 feet above normal tailwater elevation, some leaching was observed at the spillway. An accurate determination of the severity of the leaching cannot be made without further investigation beyond the scope of a Phase I inspection.

b. Generalized Soils Description

The generalized soils description of the dam site consists of silty-loams and sandy-silts with varying amounts of pebbles, gravel and boulders intermingled with silty sands, silty gravels, sandy gravels and gravelly sands. These materials overlay bedrock composed of fine grained trap rock at depths of 10 to 20 feet or greater.

c. Design and Construction Data

Analyses of structural stability and construction data for the embankment and spillway structure are not available.

d. Operating Records

No operating records are available for the dam. Reports of inspections made by the State of New Jersey in 1928 and 1968 are contained in the files of NJDEP. The dam was in good condition according to these reports.

e. Post Construction Changes

Records on file at the NJDEP indicate that the dam was originally constructed in 1903 as a stonewall-earth dam. In 1928, improvements were made to the dam by construction of a concrete retaining wall on the downstream side of the dam. A concrete cap was also built along the crest of the dam. The entire length of the dam became an overflow spillway. The original spillway was filled by clay to form the same slope as the embankment. The original section of the clay embankment was undisturbed. Six inches of concrete base overlaid with grouted stone pavement was constructed to cover the bed and sides of the downstream channel for a distance of approximately 1000 feet.

f. Seismic Stability

Verona Lake Dam is located in Seismic Zone 1 as defined in "Recommended Guideline for Safety Inspection of Dams," which is a zone of very low seismic activity. Experience indicates that dams in Seismic Zone 1 will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. Verona Lake Dam appeared to be outwardly stable under static loading conditions.

SECTION 7: ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Safety

Based on hydraulic and hydrologic analyses outlined in Section 5 and Appendix 4, the spillway of Verona Lake Dam is assessed as being inadequate. The spillway is not able to pass the SDF without an overtopping of the dam.

The dam appeared to be outwardly stable at the time of inspection. The observed leaching is not considered to be an immediate indication of instability. However, sufficient data is not available to allow a complete assessment of the present structural condition of the dam and appurtenances.

b. Adequacy of Information

Information sources for this study include 1) field inspection, 2) USGS quadrangle sheet, 3) aerial photography from Essex County, 4) plans, inspection reports and correspondence in the NJDEP file, and 5) consultation with maintenance and operation personnel of Essex County Division of Parks.

The information obtained is sufficient to allow a Phase I assessment as outlined in "Recommended Guidelines for Safety Inspection of Dams."

Some data not available are as follows:

1. Description of dam embankment structures and material.
2. Original construction records.
3. Soils Report.
4. Hydraulic and structural design reports.

c. Necessity for Additional Data/Evaluation

Additional evaluation is considered necessary in order to assess the structural stability of the dam.

7.2 Recommendations

a. Remedial Measures

Based on hydraulic and hydrologic analyses outlined in paragraph 5.1.a, the spillway is considered to be inadequate. Therefore, it is recommended that a professional engineer experienced in the design and construction of dams be engaged in the near future to perform more accurate hydraulic and hydrologic analyses relating to the spillway capacity. Based on the findings of these analyses, the need for and type of remedial measures should be determined and them implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future. With the lake drawn down, the masonry spillway should be thoroughly inspected by a professional engineer experienced in the design and construction of dams. Based on the inspection, together with any necessary subsoil, seepage and structural investigations, the need for remedial measures should be determined and the measures implemented.

b. Maintenance

In the near future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to insure the safety of the dam.

PLATES

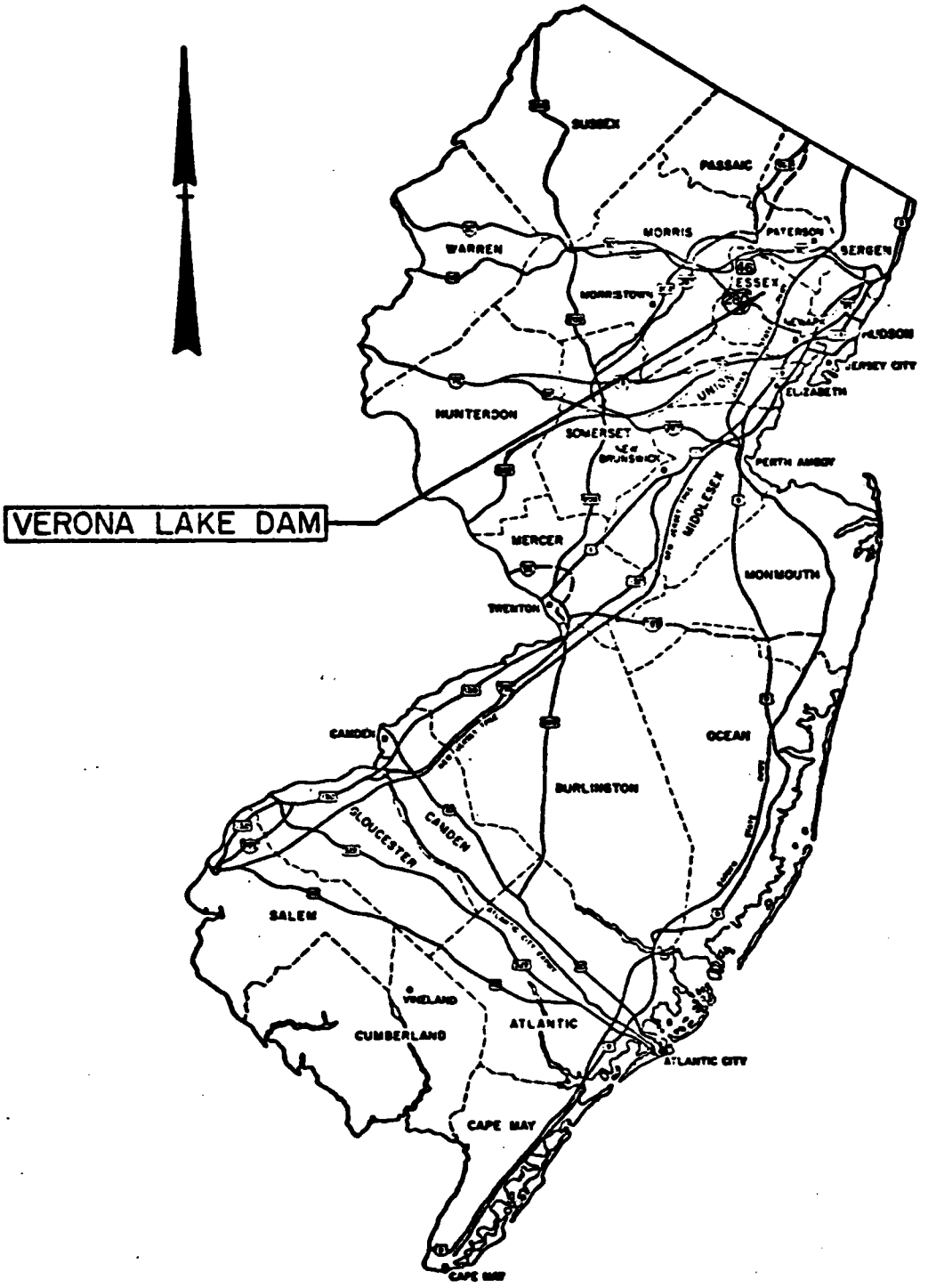


PLATE 1

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS KEY MAP VERONA LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00386 — SCALE: NONE DATE: NOV., 1979

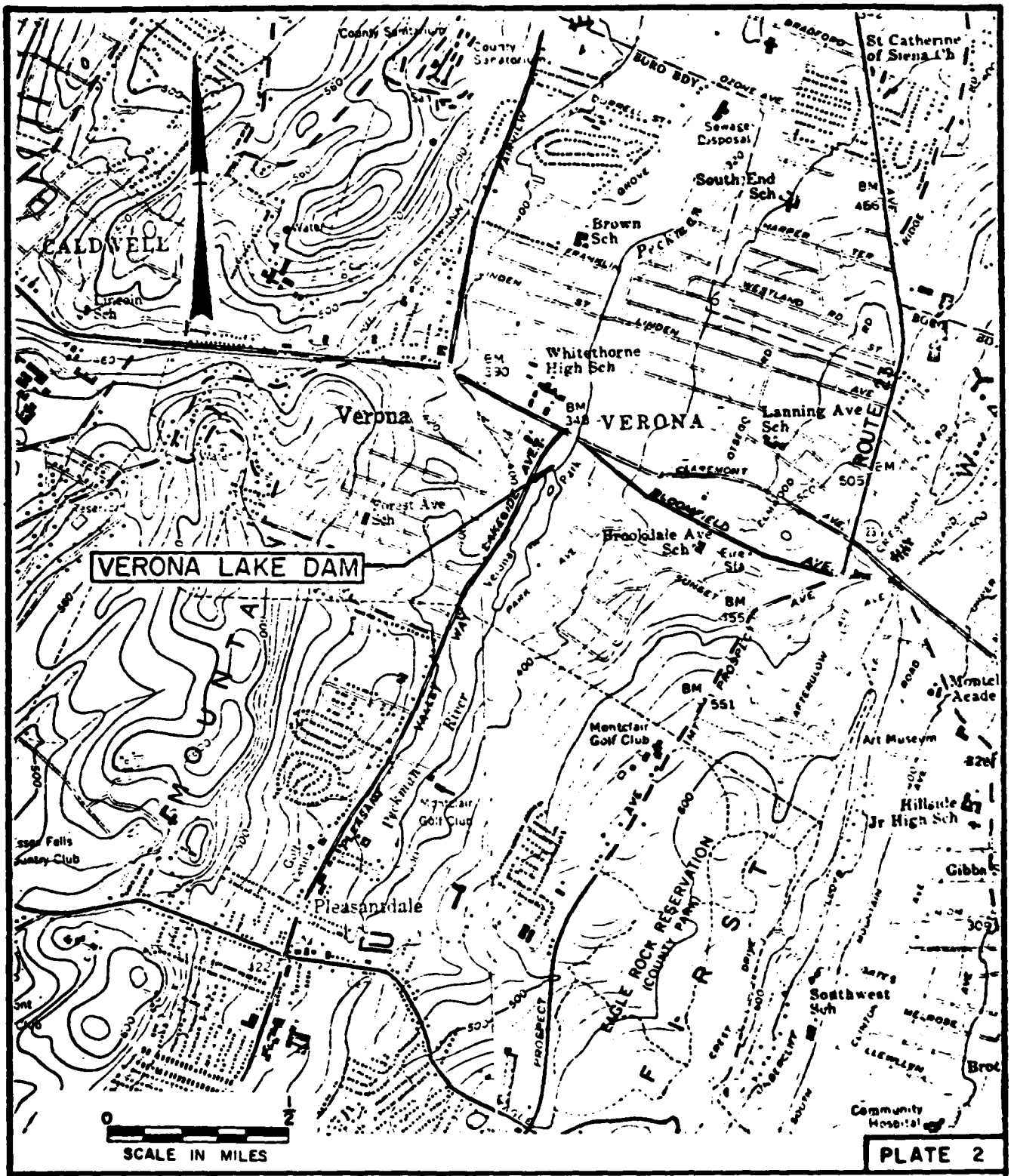
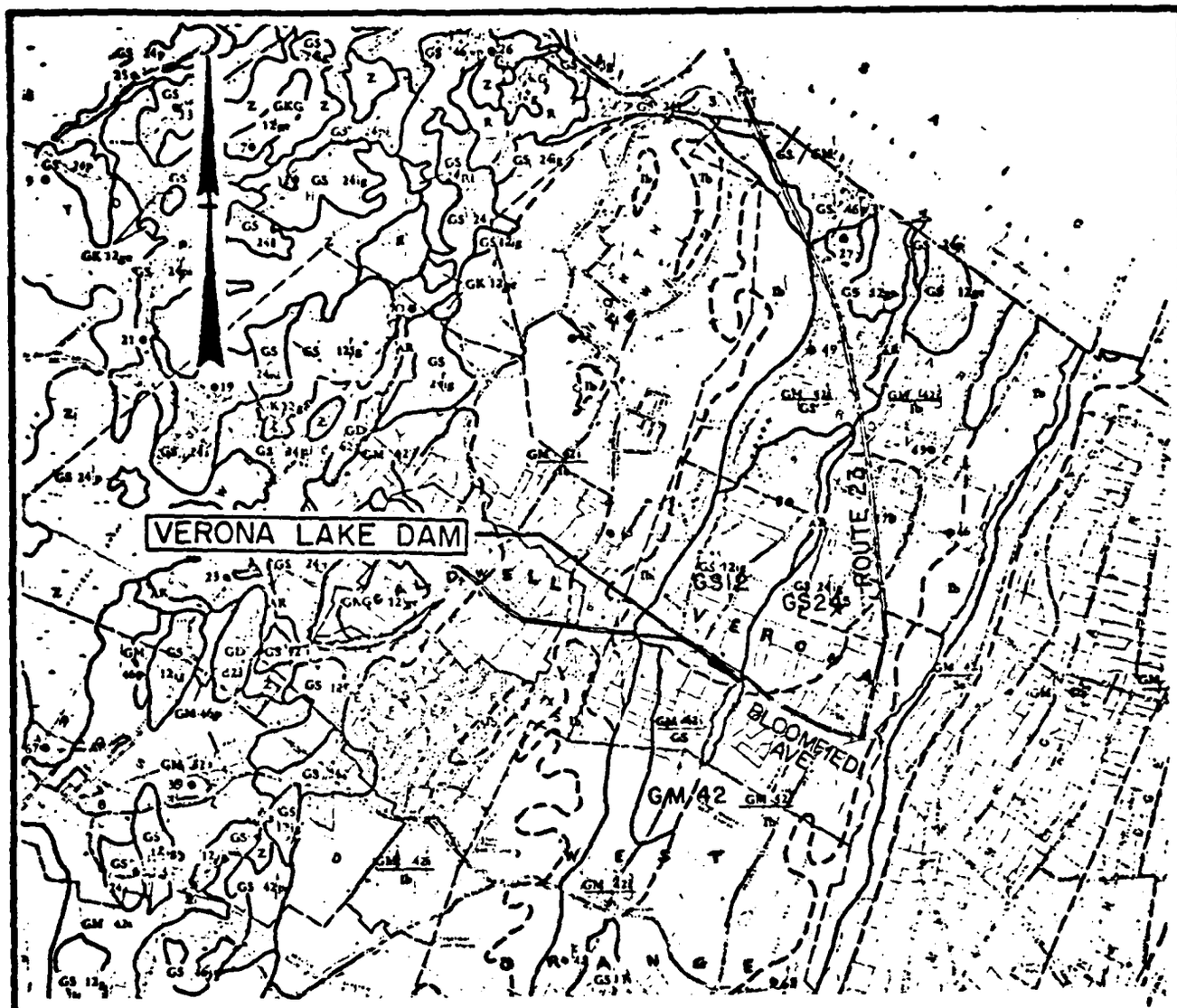


PLATE 2

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS VICINITY MAP VERONA LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00386 — SCALE: AS SHOWN DATE: NOV., 1979



Legend

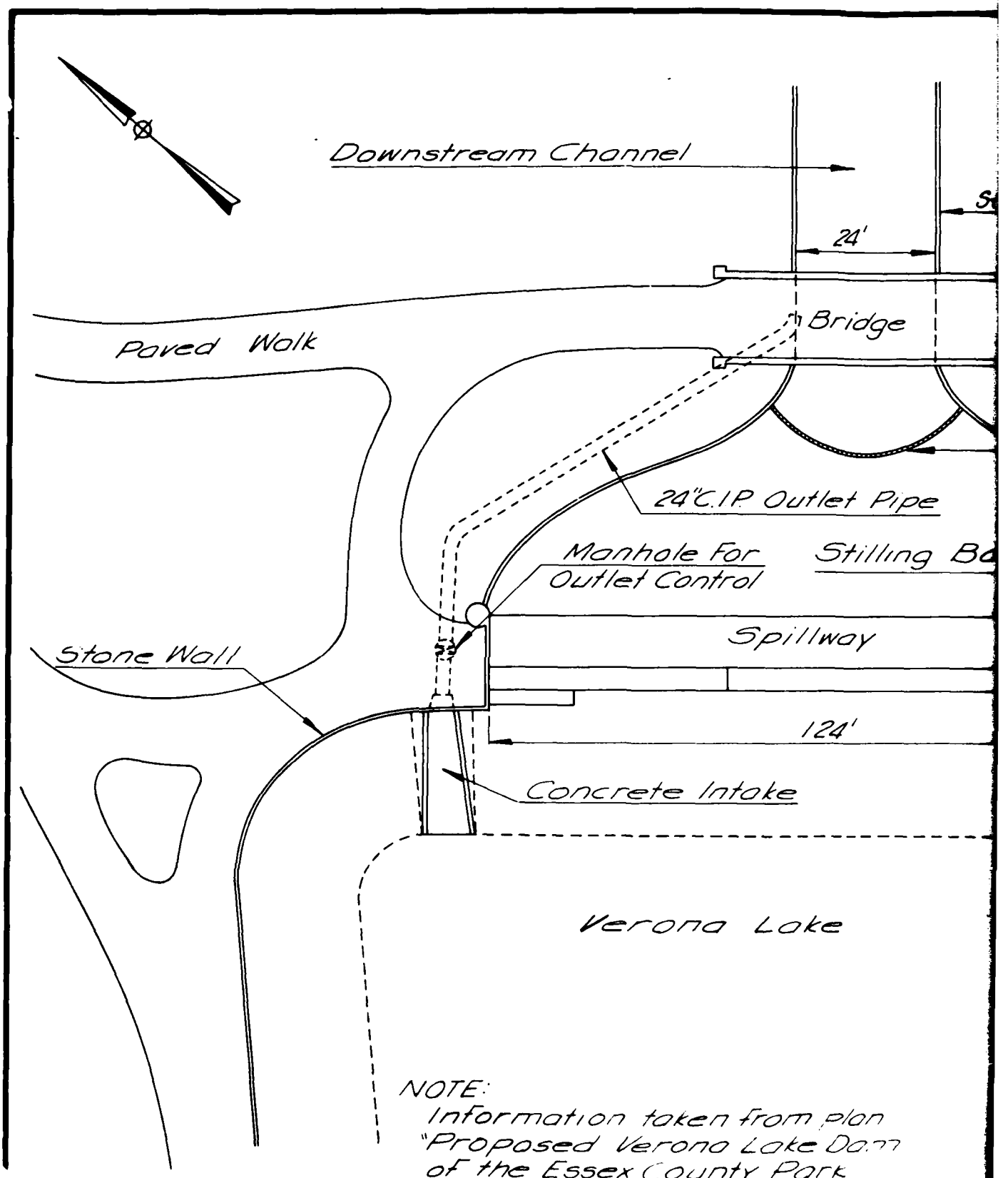
GM-42 Silty-loams and sandy-silts with varying amounts of pebbles, gravel and boulders.

GS-12 Silty sands, silty gravels, sandy gravels and gravelly sands.

NOTE: Information taken from Rutgers University Soil Survey of New Jersey, Report No. 2, Essex County, and Geologic Map of New Jersey prepared by Lewis and Kummel.

PLATE 3

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS **SOIL MAP** VERONA LAKE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. NJ00386 — SCALE: NONE DATE: NOV., 1979



NOTE:
Information taken from plan "Proposed Verona Lake Dam of the Essex County Park Commission" and field inspection. Nov. 14 1979

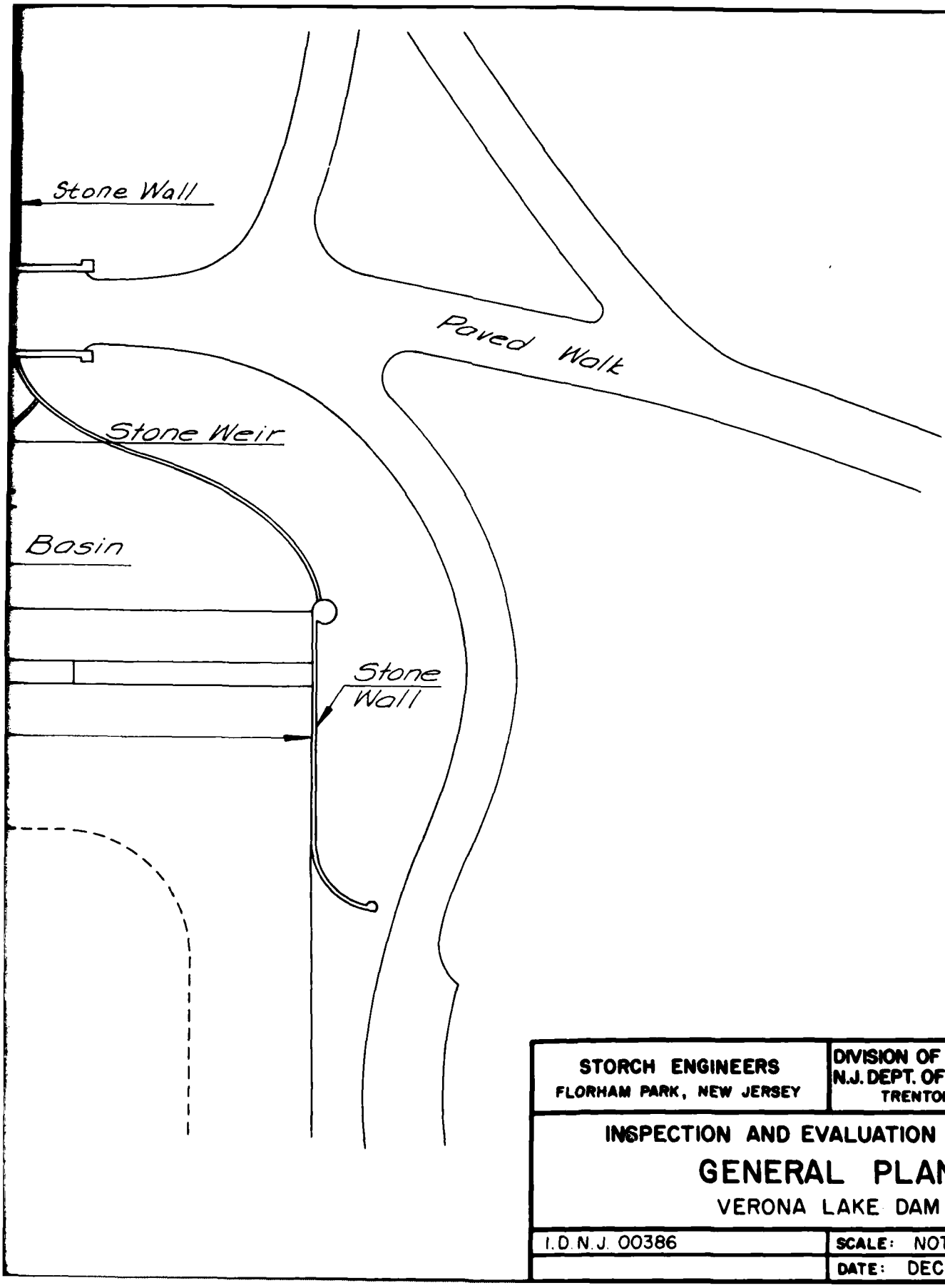


PLATE 4

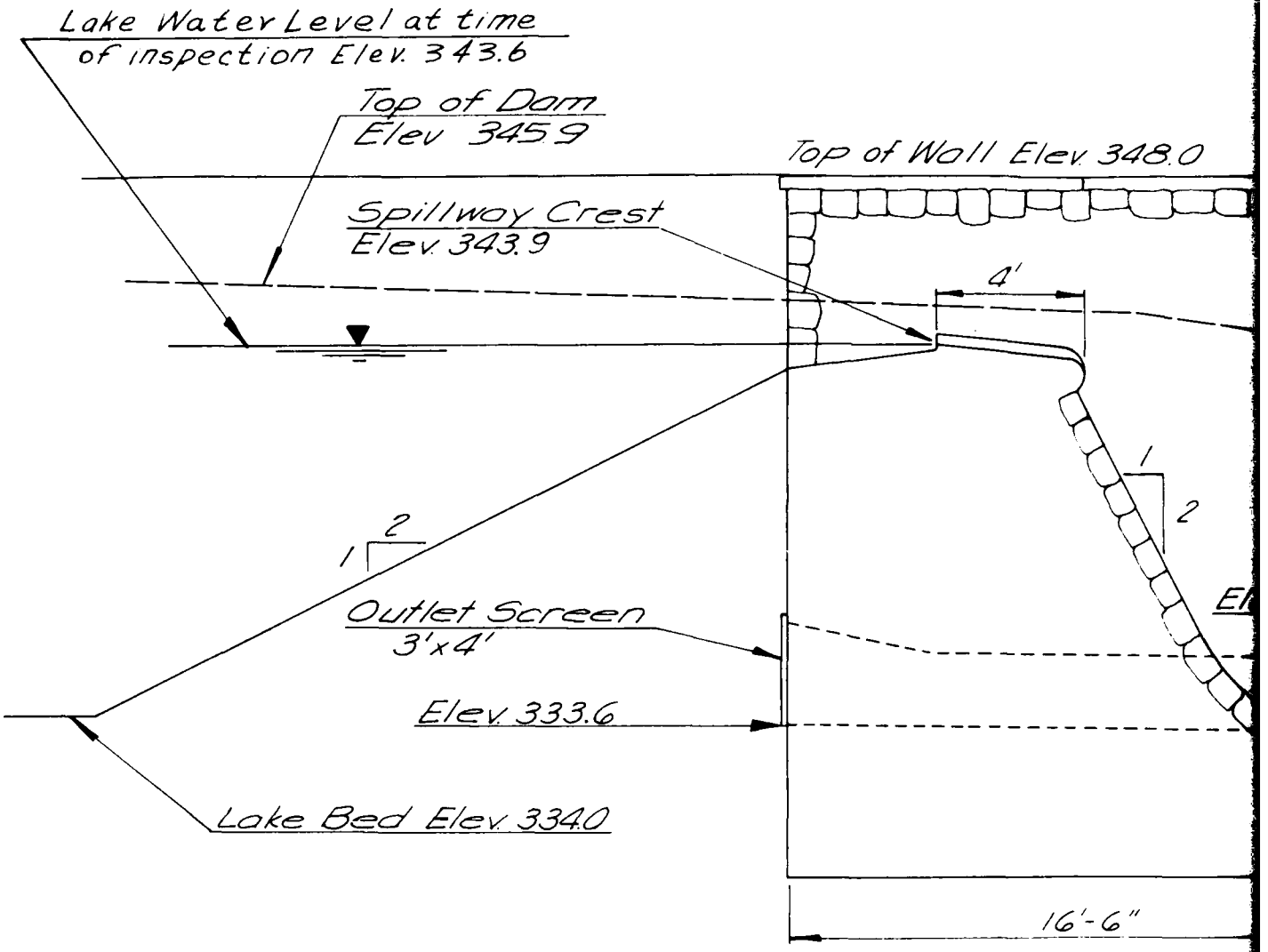
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

GENERAL PLAN

VERONA LAKE DAM

I.D.N.J. 00386	SCALE: NOT TO SCALE
	DATE: DEC., 1979



NOTES:

1. Information taken from plan "Proposed Verona Lake Dam of the Essex County Park Commission" and field inspection Nov. 14, 1979
2. Elevations based on N.G.V.D. taken from Essex Co Park

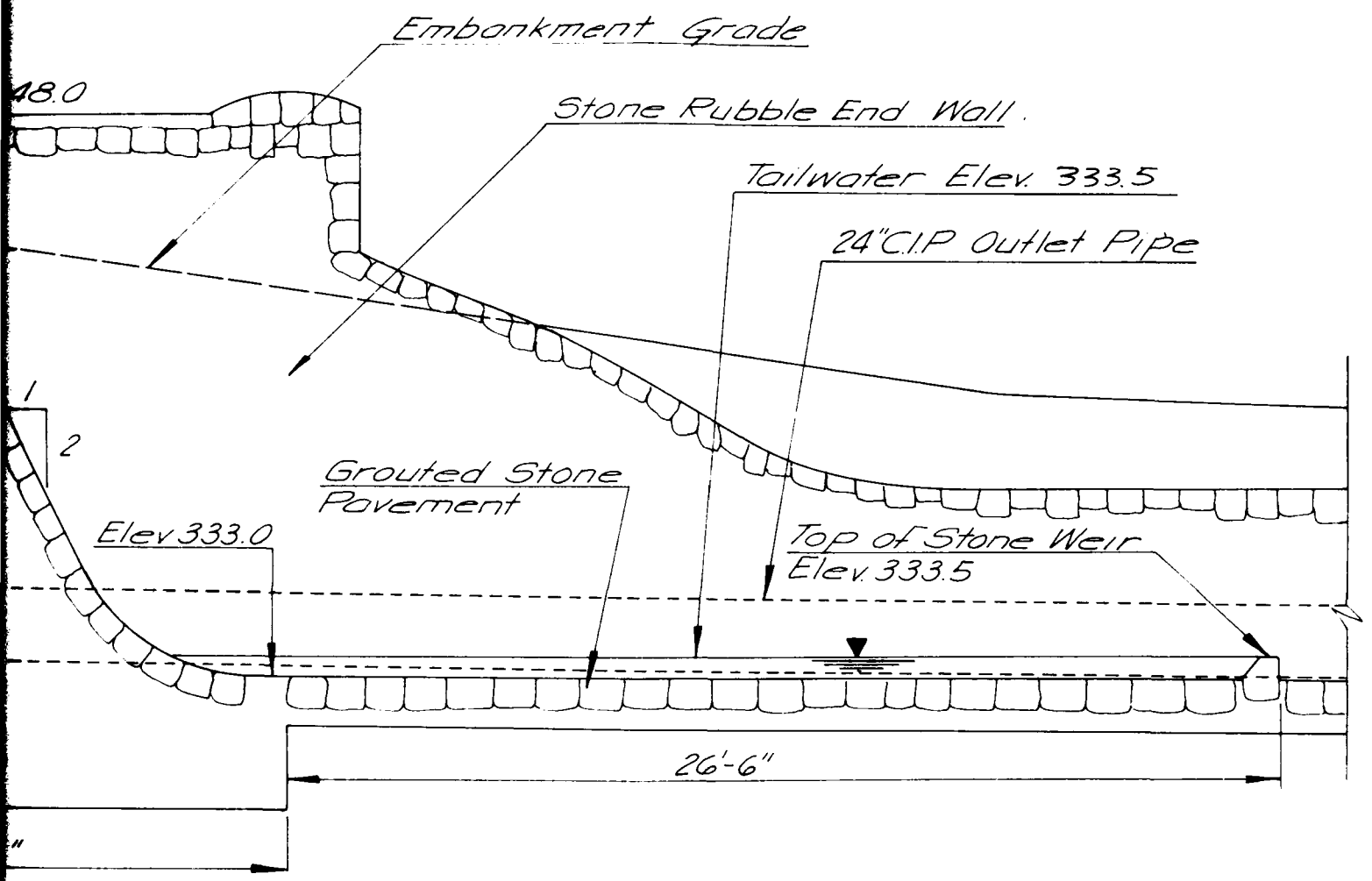


PLATE 5

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

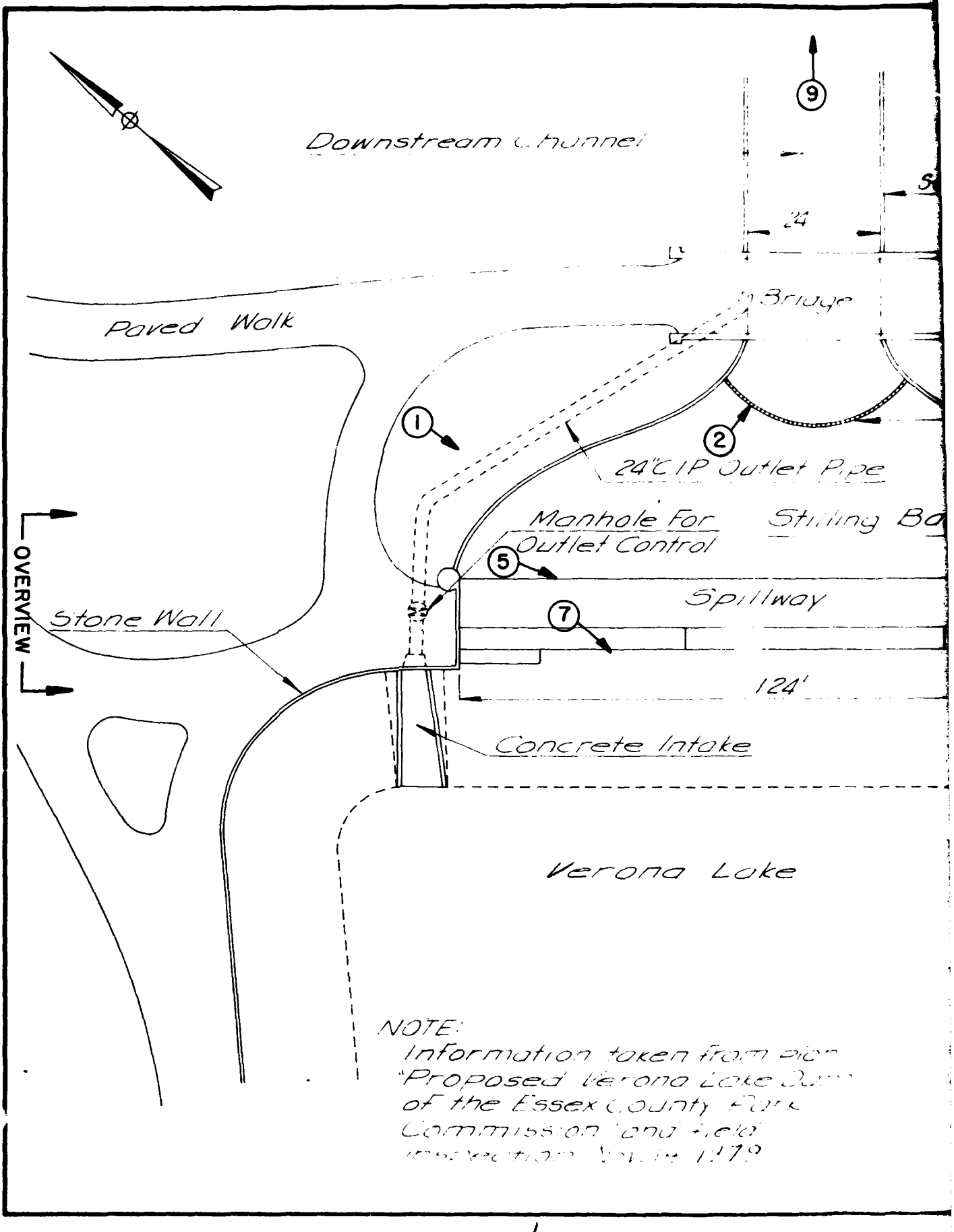
INSPECTION AND EVALUATION OF DAMS

SPILLWAY SECTION

VERONA LAKE DAM

I.D.N.J. 00386	SCALE: NOT TO SCALE
	DATE: DEC. 1979

Park Comm plans.


Downstream Channel
9
24
Bridge
Paved Walk
1
2
24"CIP Outlet Pipe
Manhole For
Outlet Control
Stilling Ba
5
Spillway
7
124'
OVERVIEW
Stone Wall
Concrete Intake
Verona Lake
NOTE:
Information taken from plan
"Proposed Verona Lake Dam
of the Essex County Park
Commission" and field

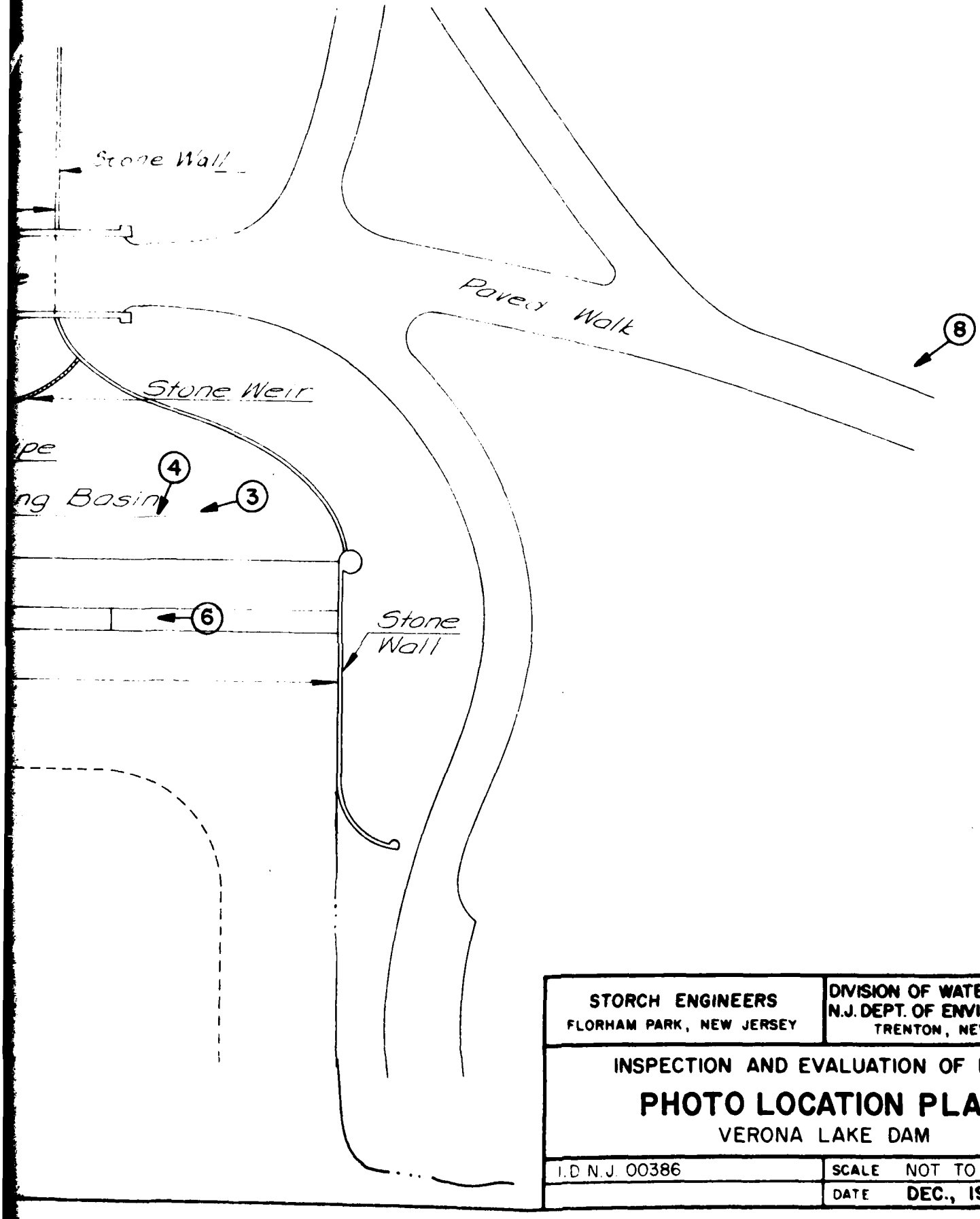


PLATE 6

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

PHOTO LOCATION PLAN

VERONA LAKE DAM

I.D N.J. 00386	SCALE NOT TO SCALE
	DATE DEC., 1979

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List
Visual Inspection
Phase I

Name of Dam Verona Lake Dam County Essex State New Jersey Coordinators NJDEP

Date(s) Inspection 11/14/79 Weather P-Cloudy Temperature 50°F

Pool Elevation at Time of Inspection 343.6 M.S.L. Tailwater at Time of Inspection 333.5 M.S.L.

Inspection Personnel:

John Gribbin Alan Volle

Ronald Lai Thomas Miller

Richard McDermott

J. Gribbin Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Stone masonry overflow appeared structurally stable. Some leaching was observed near the toe.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Junction at both ends of masonry overflow section appeared sound.	
DRAINS	None	
WATER PASSAGES	None	
APRON	Masonry apron and stilling basin appeared to be in satisfactory condition.	
VERTICAL AND HORIZONTAL ALIGNMENT	Horizontal alignment appeared to be straight. Vertical alignment of crest slightly depressed at the center.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	No major cracks were observed. Several slight surface cracks were evident along the crest of spillway.	Recommend renovation of spillway crest.
STRUCTURAL CRACKING	None observed.	
CONSTRUCTION JOINTS	No distress observed.	
MONOLITH JOINTS	N.A.	
LEAKAGE	Leakage observed immediately below crest of masonry dam.	
SEEPAGE	Evidence of leaching was observed at the base of spillway. May be due to leakage or seepage.	Recommend further investigation.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Paved walkway on crest appeared to be in satisfactory condition. Embankment generally grassed with some trees.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appeared stable.	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	None	
DRAINS	Weep holes at base of stone masonry training walls.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Alignment of crest appeared irregular.	Embankments appeared to be graded and landscaped as part of park in which dam is located.
RIPRAP FAILURES	None observed.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	N.A.	
INTAKE STRUCTURE	Intake submerged and could not be observed durjng inspection.	
OUTLET STRUCTURE	Outlet of 24" cast iron pipe appeared to be clear and in satisfactory condition.	
OUTLET CHANNEL	Same as spillway discharge channel.	
GATE AND GATE HOUSING	Manhole for gate valve control and control mechanism appeared to be in satisfactory condition.	Outlet control not operated at time of inspection.

SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Conc. weir joined by cap constructed in 1928 on top of original stone masonry structure. Appeared to be in fair condition with several transverse surface cracks.	Recommend renovation of spillway crest.
APPROACH CHANNEL	N.A.	
DISCHARGE CHANNEL	Spillway discharges into paved discharge channel. Stone masonry walls and bottom appeared to be in satisfactory condition.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Shore slopes have average pitch of approx. 5%.	
SEDIMENTATION	Sounding in the vicinity of spillway indicate silt deposit approx. 4 feet thick.	
STRUCTURES ALONG BANKS	One pedestrian bridge located on lake.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No obstruction or debris were observed in downstream channel.	Channel consists of conc. and masonry lined channel for approx. 1000 feet in park.
SLOPES	Vertical side slopes on stone masonry walls.	
STRUCTURES ALONG BANKS	No building along channel for 1000 feet downstream. Two concrete bridges for pedestrians and park vehicles located along channel within park. Concrete road bridge located 1000 feet downstream. Urban development include buildings along banks downstream from bridge in flood plain of dam.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
DAM - PLAN	Available in NJDEP file entitled " General Plan Proposed Verona Lake" by Essex County Park Commission.
SECTIONS	
SPILLWAY - PLAN	See above.
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Not Available.
OUTLETS - PLAN	Available in above plans.
DETAILS	Not Available.
CONSTRAINTS	Not Available.
DISCHARGE RATINGS	Not Available.
HYDRAULIC/HYDROLOGIC DATA	
RAINFALL/RESERVOIR RECORDS	Not Available.
CONSTRUCTION HISTORY	Information available on addition of downstream face in 1928 in NJDEP.
LOCATION MAP	Not Available.

ITEM	REMARKS
DESIGN REPORTS	Not Available
GEOLOGY REPORTS	Not Available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Not Available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Not Available
POST-CONSTRUCTION SURVEYS OF DAM	Not Available
BORROW SOURCES	Not Available

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Additions of downstream face in 1928.
HIGH POOL RECORDS	None
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	One inspection report done in 1968 is available in NJDEP file.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Records not available.
MAINTENANCE OPERATION RECORDS	Not available.

APPENDIX 2

Photographs

PHOTO 1

SPILLWAY

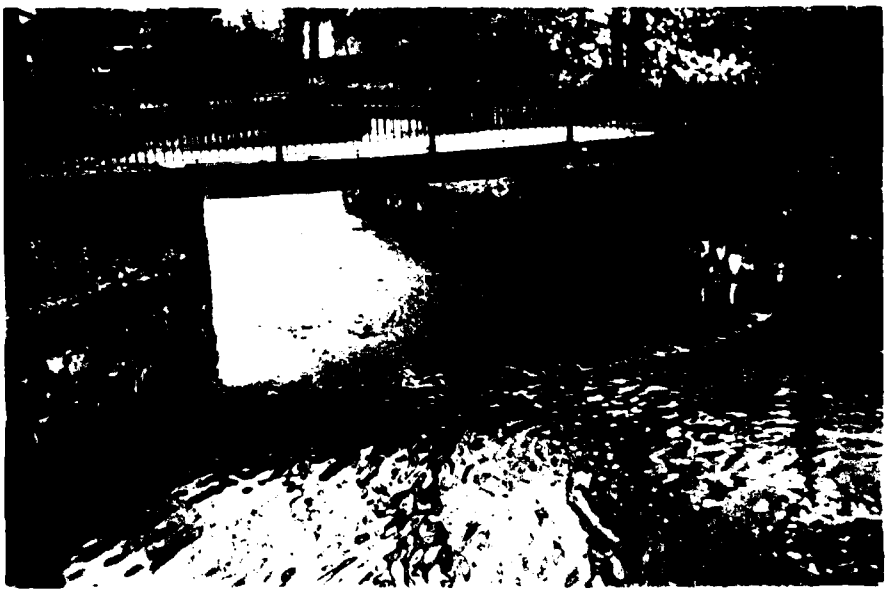


PHOTO 2

CONCRETE BRIDGE AND STONE WEIR DOWNSTREAM FROM DAM

VERONA LAKE DAM
14 NOVEMBER 1979

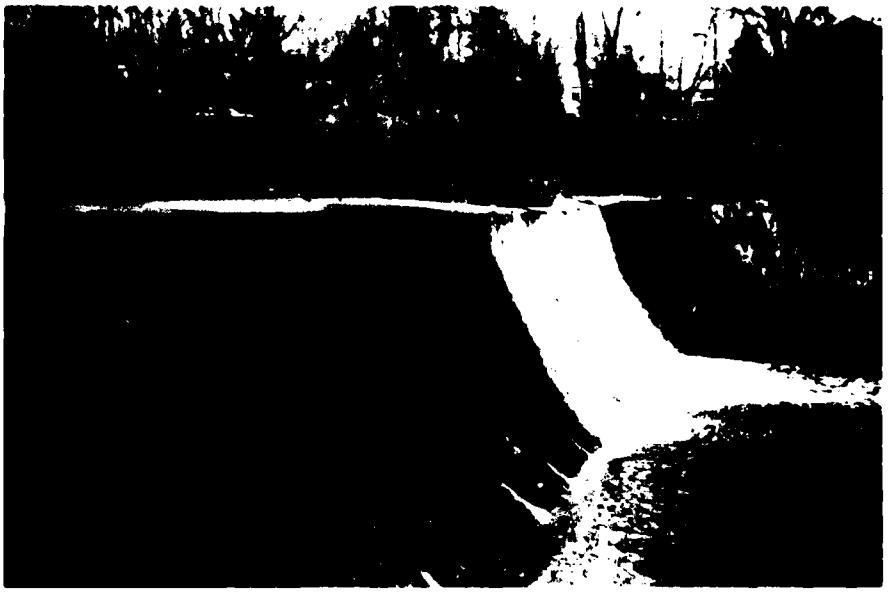


PHOTO 3

LEAKAGE AT CREST OF SPILLWAY

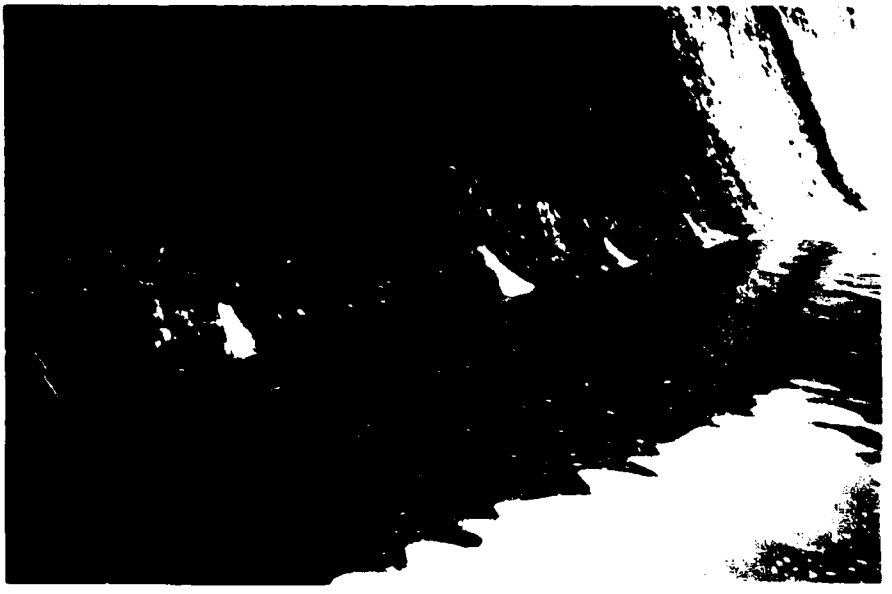


PHOTO 4

LEACHATE NEAR TOE OF SPILLWAY

VERONA LAKE DAM
14 NOVEMBER 1979

PHOTO 5

CREST AND DOWNSTREAM FACE OF SPILLWAY

PHOTO 6

CRACK IN CREST OF SPILLWAY NEAR CENTER

VERONA LAKE DAM
14 NOVEMBER 1979

PHOTO 7

UPSTREAM FACE OF EAST EMBANKMENT

PHOTO 8

DOWNSTREAM FACE OF EAST EMBANKMENT

VERONA LAKE DAM
14 NOVEMBER 1979

PHOTO 9 29 NOVEMBER 1979

DOWNSTREAM CHANNEL

PHOTO 10 14 NOVEMBER 1979

ROAD BRIDGE DOWNSTREAM FROM DAM

VERONA LAKE DAM

APPENDIX 3

Engineering Data

CHECK LIST

HYDROLOGIC AND HYDRAULIC DATA

ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Urban and Wooded

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 343.9 (60 Acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N.A.

ELEVATION MAXIMUM DESIGN POOL: 347.2

ELEVATION TOP DAM: 345.9

SPILLWAY CREST: Straight Masonry Weir

a. Elevation 343.6 to 343.9
b. Type Irregular Section
c. Width 7.5 feet
d. Length 124 feet
e. Location Spillover Center of dam
f. Number and Type of Gates None

OUTLET WORKS: 24-inch cast iron pipe with gate valve

a. Type Outlet pipe with gate valve
b. Location N/W end of dam
c. Entrance inverts 333.6
d. Exit inverts 332.7
e. Emergency draindown facilities: Gate-valve

HYDROMETEOROLOGICAL GAGES: None

a. Type N.A.
b. Location N.A.
c. Records N.A.

MAXIMUM NON-DAMAGING DISCHARGE:

(Lake stage equal to top of dam) 1076 c.f.s.
(Elev. 345.9)

APPENDIX 4

Hydraulic/Hydrologic Computations

Hydrology

Hydrologic Analysis

Runoff hydrograph will be developed by HEC-1-DB using triangular hydrograph with the curvilinear transformation.

Drainage Area = 1.9 Sq. miles

Infiltration Data

Initial infiltration	1.0 in
Constant "	0.1 in/hr.

Time of Concentration

By chart on SCS TR-55 overland flow

Overland flow	5,000 ft	5%
Channel flow	5,500 ft	1%

$$T_c = \left(\frac{5000}{1.6} + \frac{5500}{1.5}\right)\frac{1}{3600}$$

$$\doteq \underline{1.9 \text{ hour}}$$

Time of Concentration

Nomograph "Design of Small Dams"

$L = 10500 \text{ ft} \approx 2 \text{ mi}$

$H = 305$

$$T = \left(\frac{11.9 L^3}{H}\right)^{0.385}$$

$$= \left[\frac{11.9(2)^3}{305}\right]^{0.385}$$

$$= 0.64 \text{ hr.}$$

Time of Concentration

Snyder's lag

$$t = C_t (L L_{ca})^{0.3}$$

t = lag time (hr.)
C_t = 2.0
L = length of the main stream channel (mi) from the outlet to the divide
L_{ca} = length along the main channel to a point opposite the watershed centroid (mi)

$$t = 2[(2)(1.1)]^{0.3}$$

$$= 2.5 \text{ hr.}$$

Time of Concentration

By Kerby

Pg 14-36
"Handbook of Applied Hydrology" Chow
McGraw Hill

$$t_c^{2.14} = \frac{2}{3} \frac{Ln}{\sqrt{s}}$$

t_c = time of concentration in minutes
L = Length of overland flow in ft.
S = slope
n = 0.4 roughness coef.

$$t_c^{2.14} = \frac{2}{3} \frac{5000\ (0.4)}{\sqrt{0.05}}$$

t_c = 0.97 hr.

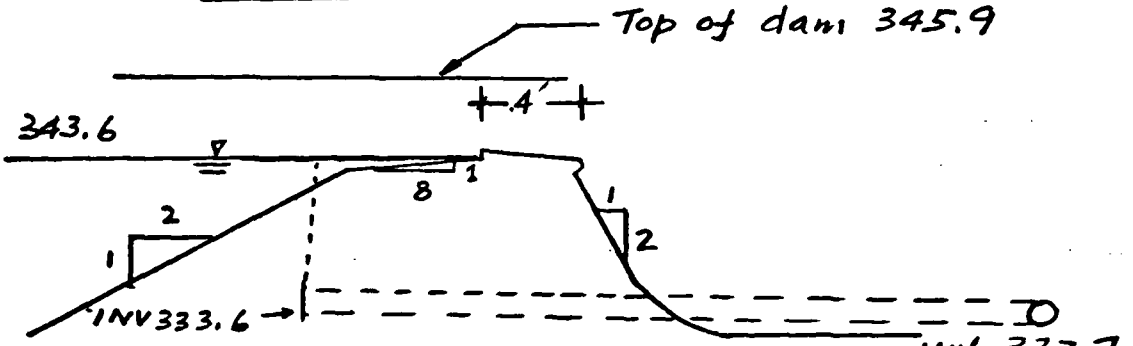
Channel flow = 1 hr

total Tc = 1.97 hr.

Use 1.9 as Tc

and $1.9 \times 0.6 = \underline{1.14}$ for Lag

Hydraulics



Spillway Section

$Q = CLH^{3/2}$ $C = 3.1$

Ref. 5-44 "Handbook of Hydraulics King et. al."

Length of Spillway = 124 feet

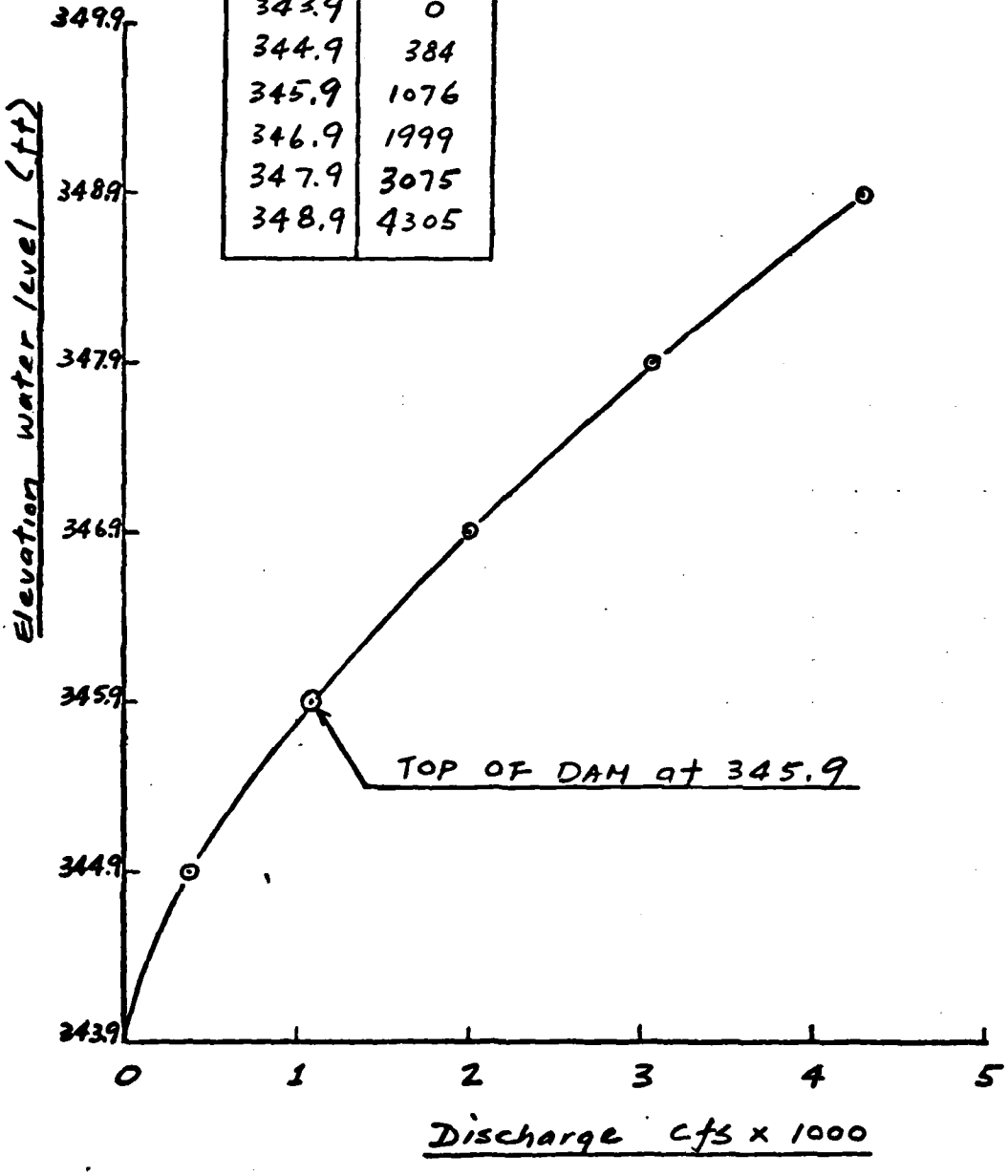
Stage Discharge Tabulation

W.L. (ft)	Head H (ft)	$H^{3/2}$	C	Q (cfs)
343.9	0	0	3.1	0
344.9	1	1	3.1	384
345.9	2	2.8	3.1	1076
346.9	3	5.2	3.1	1999
347.9	4	8.0	3.1	3075
348.9	5	11.2	3.1	4305

SPILLWAY

STAGE DISCHARGE CURVE

W.L. (ft)	Q (cfs)
343.9	0
344.9	384
345.9	1076
346.9	1999
347.9	3075
348.9	4305



Lake Storage Volume

Elev. (M.S.L.)	Surface Area (AC)
333.6	0
343.6	16.5
360.0	35.0
380.0	112.0

HEC-1-DB program will develope storage capacity from surface area and elev.

Outlet Works Capacity

24" CIP inlet at 333.6
outlet at 332.7

Approximately 90' of 24" CIP
slope of pipe = 1%

Outlet control "Hydraulic charts for the selection of Highway Culverts"
Bureau of Public Roads

For HW = 343.6
TW = 332.7

H = 10.9

Q ≐ 16 cfs

Time required for total drawdown

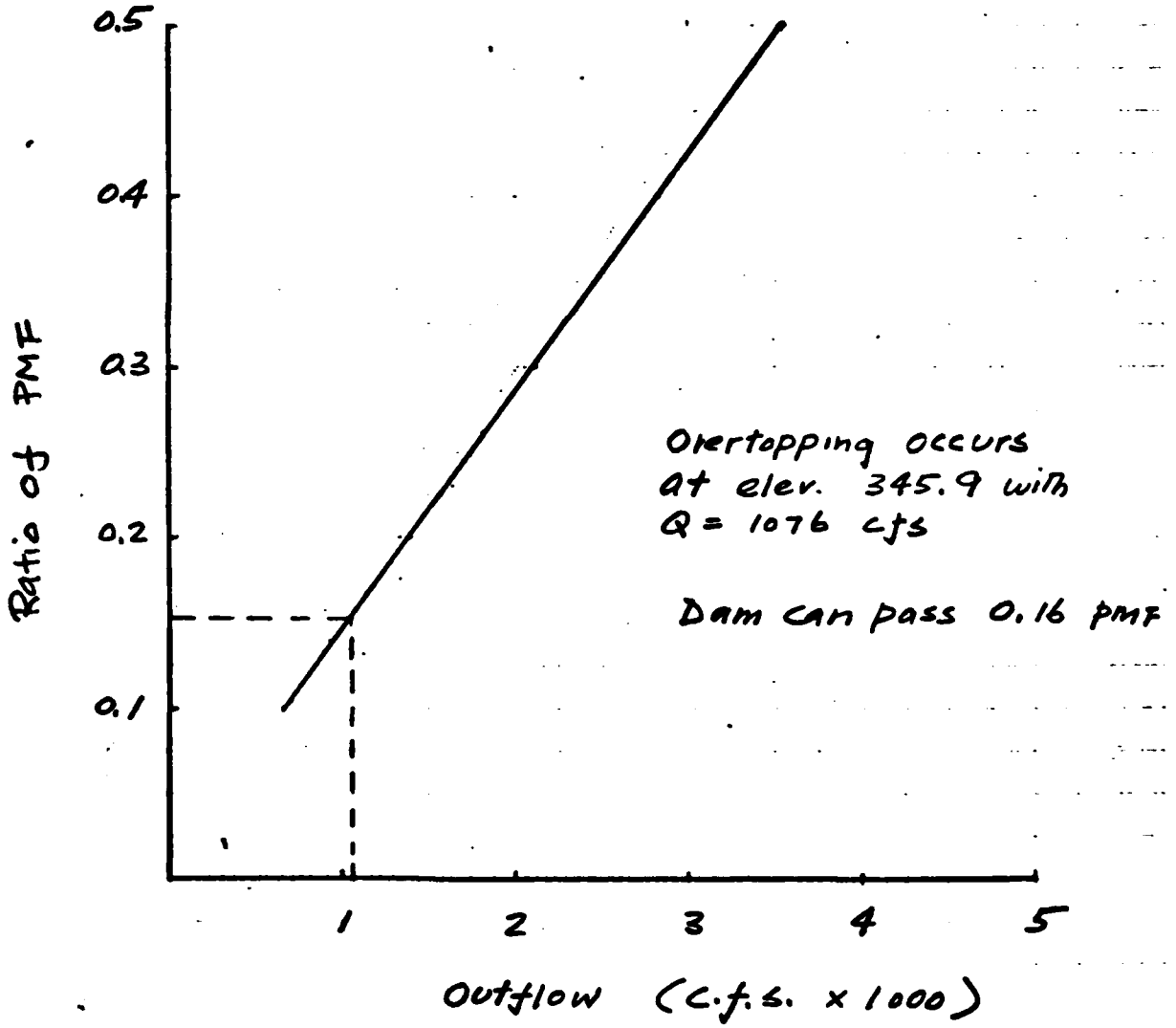
$$= \frac{\text{Total storage}}{\text{rate of drawdown}}$$ Assume inflow = 0

$$= \frac{59 \times 43560}{8 \times 3600} \text{ hrs}$$

$$\doteq \underline{\underline{89}} \text{ hrs}$$

$$\doteq \underline{\underline{3.7}} \text{ days}$$

Overtopping Potential



HEC-1-DB COMPUTATIONS

```
A1                          NATIONAL DAM SAFETY PROGRAM
A2                          VERONA LAKE DAM    NEW JEPSEY
A3                          MULTI RATIO ROUTING
B     200                     5                                                     3
B1      5
J       1       5             1
J1    0.5     0.4           0.3     0.2     0.1
K       0    LAKE                                              1
K1                          INFLOW HYDROGRAPH TO VERONA LAKE
M       1       2           1.9             1.9                                     1
P            25.7           100     109     117
T                                                            1.0      0.1
J2           1.14
X    -1.0   -0.05           2.0
K       1     DAM                                              1
K1                          ROUTE DISCHARGE THRU DAM
Y                                     1       1
Y1      1                                                  -343.6      -1
Y4  343.9   344.9         345.9   346.9   347.9   348.9
Y5      0     384          1076    1999    3075    4305
$A      0    16.5            35     112
$E  333.6   343.6           360     380
$$  343.9
$D  345.9    2.63           1.5     314
K      99
A
A
A
A
A
```

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 79/12/28.
     TIME= 10.04.53.
```

NATIONAL DAM SAFETY PROGRAM
VERONA LAKE DAM NEW JERSEY
MULTI RATIO ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
200	0	5	0	0	0	0	0	3	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1

RTIOS= .50 .40 .30 .20 .10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO VERONA LAKE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LAKE	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.90	0.00	1.90	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.70	100.00	109.00	117.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

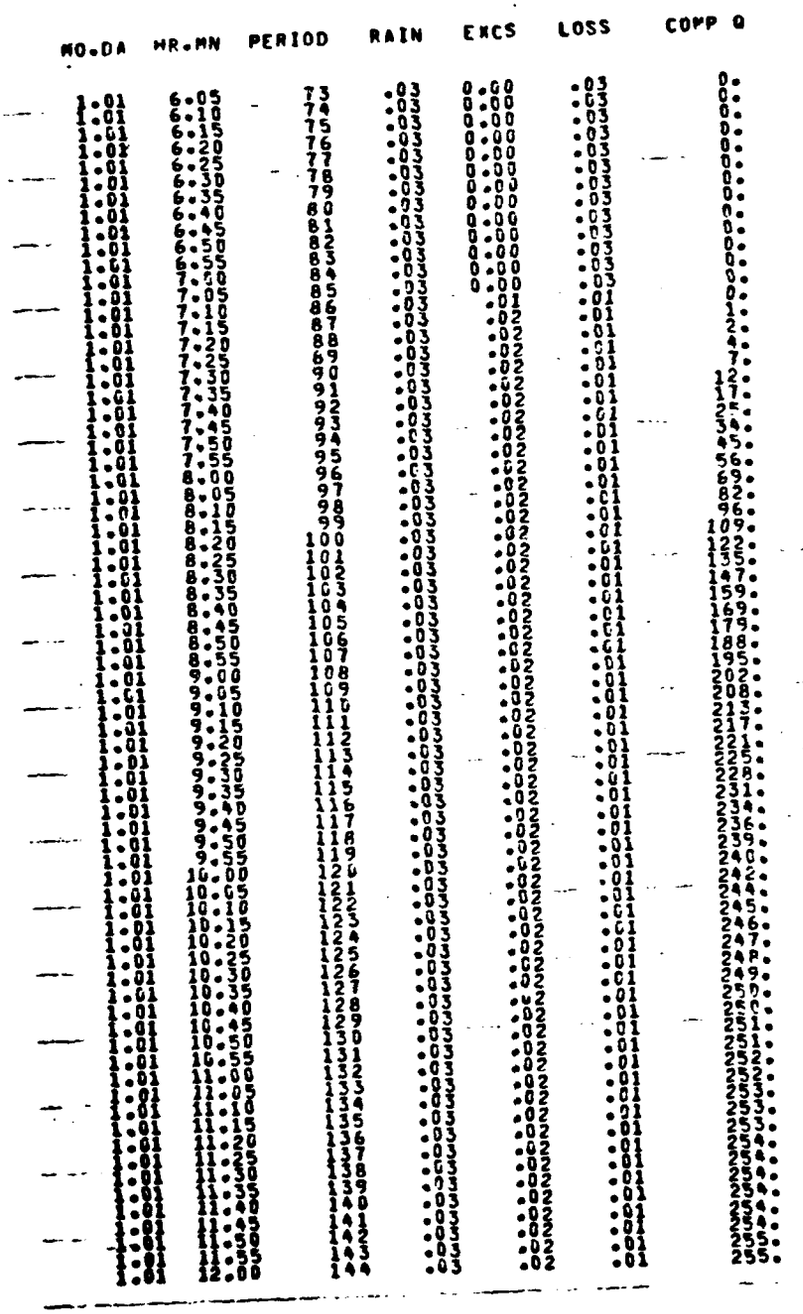
UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.14

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 70 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 1.14 VOL= 1.00

16.	46.	86.	135.	197.	269.	357.	460.	556.	641.
701.	744.	770.	775.	772.	755.	723.	684.	643.	597.
543.	480.	418.	363.	323.	287.	255.	227.	205.	185.
165.	148.	131.	115.	104.	93.	82.	74.	66.	58.
52.	46.	41.	37.	33.	29.	26.	23.	21.	19.
16.	15.	13.	12.	10.	9.	8.	8.	7.	6.
6.	5.	4.	4.	3.	3.	2.	2.	1.	0.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	2.
1.01	.10	2	.01	0.00	.01	2.
1.01	.15	3	.01	0.00	.01	2.
1.01	.20	4	.01	0.00	.01	1.
1.01	.25	5	.01	0.00	.01	1.
1.01	.30	6	.01	0.00	.01	1.
1.01	.35	7	.01	0.00	.01	1.
1.01	.40	8	.01	0.00	.01	1.
1.01	.45	9	.01	0.00	.01	1.
1.01	.50	10	.01	0.00	.01	1.
1.01	.55	11	.01	0.00	.01	1.
1.01	1.00	12	.01	0.00	.01	1.
1.01	1.05	13	.01	0.00	.01	1.
1.01	1.10	14	.01	0.00	.01	1.
1.01	1.15	15	.01	0.00	.01	1.
1.01	1.20	16	.01	0.00	.01	1.
1.01	1.25	17	.01	0.00	.01	1.
1.01	1.30	18	.01	0.00	.01	1.
1.01	1.35	19	.01	0.00	.01	1.
1.01	1.40	20	.01	0.00	.01	1.
1.01	1.45	21	.01	0.00	.01	1.
1.01	1.50	22	.01	0.00	.01	1.
1.01	1.55	23	.01	0.00	.01	1.
1.01	2.00	24	.01	0.00	.01	1.
1.01	2.05	25	.01	0.00	.01	0.
1.01	2.10	26	.01	0.00	.01	0.
1.01	2.15	27	.01	0.00	.01	0.
1.01	2.20	28	.01	0.00	.01	0.
1.01	2.25	29	.01	0.00	.01	0.
1.01	2.30	30	.01	0.00	.01	0.
1.01	2.35	31	.01	0.00	.01	0.
1.01	2.40	32	.01	0.00	.01	0.
1.01	2.45	33	.01	0.00	.01	0.
1.01	2.50	34	.01	0.00	.01	0.
1.01	2.55	35	.01	0.00	.01	0.
1.01	3.00	36	.01	0.00	.01	0.
1.01	3.05	37	.01	0.00	.01	0.
1.01	3.10	38	.01	0.00	.01	0.
1.01	3.15	39	.01	0.00	.01	0.
1.01	3.20	40	.01	0.00	.01	0.
1.01	3.25	41	.01	0.00	.01	0.
1.01	3.30	42	.01	0.00	.01	0.
1.01	3.35	43	.01	0.00	.01	0.
1.01	3.40	44	.01	0.00	.01	0.
1.01	3.45	45	.01	0.00	.01	0.
1.01	3.50	46	.01	0.00	.01	0.
1.01	3.55	47	.01	0.00	.01	0.
1.01	4.00	48	.01	0.00	.01	0.
1.01	4.05	49	.01	0.00	.01	0.
1.01	4.10	50	.01	0.00	.01	0.
1.01	4.15	51	.01	0.00	.01	0.
1.01	4.20	52	.01	0.00	.01	0.
1.01	4.25	53	.01	0.00	.01	0.
1.01	4.30	54	.01	0.00	.01	0.
1.01	4.35	55	.01	0.00	.01	0.
1.01	4.40	56	.01	0.00	.01	0.
1.01	4.45	57	.01	0.00	.01	0.
1.01	4.50	58	.01	0.00	.01	0.
1.01	4.55	59	.01	0.00	.01	0.
1.01	5.00	60	.01	0.00	.01	0.
1.01	5.05	61	.01	0.00	.01	0.
1.01	5.10	62	.01	0.00	.01	0.
1.01	5.15	63	.01	0.00	.01	0.
1.01	5.20	64	.01	0.00	.01	0.
1.01	5.25	65	.01	0.00	.01	0.
1.01	5.30	66	.01	0.00	.01	0.
1.01	5.35	67	.01	0.00	.01	0.
1.01	5.40	68	.01	0.00	.01	0.
1.01	5.45	69	.01	0.00	.01	0.
1.01	5.50	70	.01	0.00	.01	0.
1.01	5.55	71	.01	0.00	.01	0.
1.01	6.00	72	.01	0.00	.01	0.


MO.DA
HR.MN
PERIOD
RAIN
EXCS
LOSS
COMP Q

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	12.05	145	.17	.16	.01	257.
1.01	12.10	146	.17	.16	.01	264.
1.01	12.15	147	.17	.16	.01	277.
1.01	12.20	148	.17	.16	.01	296.
1.01	12.25	149	.17	.16	.01	325.
1.01	12.30	150	.17	.16	.01	364.
1.01	12.35	151	.17	.16	.01	416.
1.01	12.40	152	.17	.16	.01	483.
1.01	12.45	153	.17	.16	.01	564.
1.01	12.50	154	.17	.16	.01	658.
1.01	12.55	155	.17	.16	.01	760.
1.01	13.00	156	.17	.16	.01	868.
1.01	13.05	157	.21	.20	.01	981.
1.01	13.10	158	.21	.20	.01	1095.
1.01	13.15	159	.21	.20	.01	1211.
1.01	13.20	160	.21	.20	.01	1325.
1.01	13.25	161	.21	.20	.01	1437.
1.01	13.30	162	.21	.20	.01	1546.
1.01	13.35	163	.21	.20	.01	1652.
1.01	13.40	164	.21	.20	.01	1755.
1.01	13.45	165	.21	.20	.01	1855.
1.01	13.50	166	.21	.20	.01	1945.
1.01	13.55	167	.21	.20	.01	2030.
1.01	14.00	168	.21	.20	.01	2108.
1.01	14.05	169	.26	.25	.01	2182.
1.01	14.10	170	.26	.25	.01	2253.
1.01	14.15	171	.26	.25	.01	2321.
1.01	14.20	172	.26	.25	.01	2387.
1.01	14.25	173	.26	.25	.01	2451.
1.01	14.30	174	.26	.25	.01	2516.
1.01	14.35	175	.26	.25	.01	2580.
1.01	14.40	176	.26	.25	.01	2646.
1.01	14.45	177	.26	.25	.01	2712.
1.01	14.50	178	.26	.25	.01	2778.
1.01	14.55	179	.26	.25	.01	2843.
1.01	15.00	180	.26	.25	.01	2907.
1.01	15.05	181	.16	.15	.01	2966.
1.01	15.10	182	.31	.30	.01	3027.
1.01	15.15	183	.31	.30	.01	3083.
1.01	15.20	184	.47	.46	.01	3141.
1.01	15.25	185	.55	.54	.01	3202.
1.01	15.30	186	1.33	1.32	.01	3284.
1.01	15.35	187	2.19	2.18	.01	3412.
1.01	15.40	188	.86	.85	.01	3588.
1.01	15.45	189	.55	.54	.01	3812.
1.01	15.50	190	.47	.46	.01	4084.
1.01	15.55	191	.31	.30	.01	4409.
1.01	16.00	192	.31	.30	.01	4785.
1.01	16.05	193	.24	.23	.01	5211.
1.01	16.10	194	.24	.23	.01	5664.
1.01	16.15	195	.24	.23	.01	6095.
1.01	16.20	196	.24	.23	.01	6471.
1.01	16.25	197	.24	.23	.01	6764.
1.01	16.30	198	.24	.23	.01	6976.
1.01	16.35	199	.24	.23	.01	7106.
1.01	16.40	200	.24	.23	.01	7155.
0.00	0.00	201	.24	.23	.01	7141.
0.00	0.00	202	.24	.23	.01	7062.
0.00	0.00	203	.24	.23	.01	6925.
0.00	0.00	204	.24	.23	.01	6751.
0.00	0.00	205	.19	.18	.01	6547.
0.00	0.00	206	.19	.18	.01	6313.
0.00	0.00	207	.19	.18	.01	6046.
0.00	0.00	208	.19	.18	.01	5758.
0.00	0.00	209	.19	.18	.01	5472.
0.00	0.00	210	.19	.18	.01	5211.
0.00	0.00	211	.19	.18	.01	4983.
0.00	0.00	212	.19	.18	.01	4775.
0.00	0.00	213	.19	.18	.01	4584.
0.00	0.00	214	.19	.18	.01	4413.
0.00	0.00	215	.19	.18	.01	4257.
0.00	0.00	216	.19	.18	.01	4113.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
0.00	0.00	217	.01	.01	.01	3972.
0.00	0.00	218	.01	.01	.01	3837.
0.00	0.00	219	.01	.01	.01	3701.
0.00	0.00	220	.01	.01	.01	3564.
0.00	0.00	221	.01	.01	.01	3431.
0.00	0.00	222	.01	.01	.01	3293.
0.00	0.00	223	.01	.01	.01	3147.
0.00	0.00	224	.01	.01	.01	2992.
0.00	0.00	225	.01	.01	.01	2826.
0.00	0.00	226	.01	.01	.01	2653.
0.00	0.00	227	.01	.01	.01	2477.
0.00	0.00	228	.01	.01	.01	2299.
0.00	0.00	229	.01	.01	.01	2123.
0.00	0.00	230	.01	.01	.01	1951.
0.00	0.00	231	.01	.01	.01	1782.
0.00	0.00	232	.01	.01	.01	1621.
0.00	0.00	233	.01	.01	.01	1469.
0.00	0.00	234	.01	.01	.01	1325.
0.00	0.00	235	.01	.01	.01	1192.
0.00	0.00	236	.01	.01	.01	1069.
0.00	0.00	237	.01	.01	.01	957.
0.00	0.00	238	.01	.01	.01	858.
0.00	0.00	239	.01	.01	.01	771.
0.00	0.00	240	.01	.01	.01	696.
0.00	0.00	241	.01	.01	.01	629.
0.00	0.00	242	.01	.01	.01	570.
0.00	0.00	243	.01	.01	.01	517.
0.00	0.00	244	.01	.01	.01	471.
0.00	0.00	245	.01	.01	.01	429.
0.00	0.00	246	.01	.01	.01	391.
0.00	0.00	247	.01	.01	.01	357.
0.00	0.00	248	.01	.01	.01	333.
0.00	0.00	249	.01	.01	.01	311.
0.00	0.00	250	.01	.01	.01	290.
0.00	0.00	251	.01	.01	.01	270.
0.00	0.00	252	.01	.01	.01	252.
0.00	0.00	253	.01	.01	.01	235.
0.00	0.00	254	.01	.01	.01	220.
0.00	0.00	255	.01	.01	.01	205.
0.00	0.00	256	.01	.01	.01	191.
0.00	0.00	257	.01	.01	.01	178.
0.00	0.00	258	.01	.01	.01	166.
0.00	0.00	259	.01	.01	.01	155.
0.00	0.00	260	.01	.01	.01	145.
0.00	0.00	261	.01	.01	.01	135.
0.00	0.00	262	.01	.01	.01	126.
0.00	0.00	263	.01	.01	.01	118.
0.00	0.00	264	.01	.01	.01	111.
0.00	0.00	265	.01	.01	.01	107.
0.00	0.00	266	.01	.01	.01	104.
0.00	0.00	267	.01	.01	.01	101.
0.00	0.00	268	.01	.01	.01	98.
0.00	0.00	269	.01	.01	.01	95.
0.00	0.00	270	.01	.01	.01	93.
0.00	0.00	271	.01	.01	.01	91.
0.00	0.00	272	.01	.01	.01	90.
0.00	0.00	273	.01	.01	.01	88.
0.00	0.00	274	.01	.01	.01	87.
0.00	0.00	275	.01	.01	.01	85.
0.00	0.00	276	.01	.01	.01	84.
0.00	0.00	277	.01	.01	.01	83.
0.00	0.00	278	.01	.01	.01	82.
0.00	0.00	279	.01	.01	.01	82.
0.00	0.00	280	.01	.01	.01	81.
0.00	0.00	281	.01	.01	.01	80.
0.00	0.00	282	.01	.01	.01	80.
0.00	0.00	283	.01	.01	.01	80.
0.00	0.00	284	.01	.01	.01	79.
0.00	0.00	285	.01	.01	.01	79.
0.00	0.00	286	.01	.01	.01	79.
0.00	0.00	287	.01	.01	.01	79.
0.00	0.00	288	.01	.01	.01	79.
		SUM	24.06	21.37	2.69	313120.
			(611.)	(543.)	(68.)	(8866.57)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7155.	3822.	1087.	1087.	313087.
CMS	203.	108.	31.	31.	8866.
INCHES		18.71	21.29	21.29	21.29
MM		475.28	540.76	540.76	540.76
AC-FT		1895.	2156.	2156.	2156.
THOUS CU M		2338.	2660.	2660.	2660.

HYDROGRAPH AT STA LAKE FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3577.	1911.	544.	544.	156543.
CMS	101.	54.	15.	15.	4433.
INCHES		9.36	10.64	10.64	10.64
MM		237.64	270.38	270.38	270.38
AC-FT		948.	1078.	1078.	1078.
THOUS CU M		1169.	1330.	1330.	1330.

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HYDROGRAPH ROUTING

ROUTE DISCHARGE THRU DAM

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	DAM	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-344.	-1

STAGE	343.90	344.90	345.90	346.90	347.90	348.90
FLOW	0.00	384.00	1076.00	1999.00	3075.00	4305.00

SURFACE AREA=	0.	17.	35.	112.
CAPACITY=	0.	55.	468.	1865.
ELEVATION=	334.	344.	360.	380.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
343.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
345.9	2.6	1.5	314.

STATION DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	10.	22.	33.	43.
52.	60.	67.	74.	80.	85.	89.	93.	97.	100.
103.	106.	108.	110.	112.	114.	115.	117.	118.	119.
120.	121.	121.	122.	123.	123.	124.	124.	125.	125.
125.	126.	126.	126.	126.	127.	128.	130.	134.	139.
147.	158.	173.	192.	215.	242.	273.	308.	345.	397.
458.	526.	590.	651.	709.	765.	818.	867.	914.	959.
1001.	1041.	1080.	1135.	1187.	1233.	1276.	1316.	1354.	1390.
1424.	1457.	1488.	1519.	1549.	1582.	1625.	1683.	1763.	1865.
1993.	2147.	2330.	2536.	2754.	2974.	3170.	3326.	3442.	3515.
3550.	3551.	3519.	3459.	3379.	3282.	3169.	3041.	2906.	2773.
2652.	2538.	2433.	2337.	2249.	2168.	2094.	2022.	1953.	1886.
1819.	1753.	1685.	1615.	1541.	1464.	1385.	1304.	1224.	1145.
1073.	1023.	966.	905.	842.	778.	715.	654.	597.	543.
493.	448.	406.	375.	354.	333.	313.	293.	275.	257.
241.	225.	211.	197.	184.	172.	161.	150.	140.	131.
122.	114.	106.	99.	93.	87.	82.	77.	73.	69.
66.	63.	60.	58.	56.	54.	52.	50.	49.	48.
47.	46.	45.	44.	44.	43.	42.	42.		

STORAGE

55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	55.	55.	55.	55.	55.	55.
55.	55.	55.	55.	56.	56.	56.	56.	56.	57.
57.	58.	58.	59.	59.	60.	60.	61.	61.	62.
62.	63.	63.	63.	63.	64.	64.	64.	64.	64.
65.	65.	65.	65.	65.	65.	65.	65.	65.	65.
65.	65.	65.	65.	65.	65.	65.	65.	65.	65.
66.	66.	66.	66.	66.	66.	66.	66.	66.	66.
66.	67.	68.	68.	70.	71.	72.	74.	75.	77.
79.	81.	83.	84.	86.	87.	89.	90.	91.	92.
93.	94.	96.	96.	97.	98.	98.	99.	99.	100.
100.	101.	101.	101.	102.	102.	103.	103.	104.	105.
107.	108.	110.	112.	114.	116.	117.	119.	120.	120.
121.	121.	120.	120.	119.	118.	117.	116.	115.	114.
113.	112.	111.	110.	109.	108.	108.	107.	106.	105.
105.	104.	103.	103.	102.	101.	100.	99.	98.	97.
95.	94.	92.	91.	89.	87.	86.	84.	83.	81.
80.	79.	78.	77.	76.	75.	74.	73.	72.	71.
71.	70.	69.	69.	68.	68.	67.	67.	66.	66.
65.	65.	65.	64.	64.	64.	64.	63.	63.	63.
63.	63.	63.	63.	62.	62.	62.	62.	62.	62.
62.	62.	62.	62.	62.	62.	62.	62.		

STAGE

343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.5	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.5	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.5
343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6	343.6
343.6	343.6	343.6	343.6	343.6	343.6	343.7	343.7	343.7	343.7
343.7	343.8	343.8	343.8	343.9	343.9	343.9	344.0	344.0	344.0
344.0	344.1	344.1	344.1	344.1	344.1	344.1	344.1	344.2	344.2
344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2
344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2
344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.2	344.3
344.3	344.3	344.4	344.4	344.5	344.5	344.6	344.7	344.8	344.9
345.0	345.1	345.2	345.3	345.4	345.5	345.5	345.6	345.7	345.7
345.8	345.8	345.9	346.0	346.0	346.0	346.1	346.1	346.1	346.1
346.2	346.2	346.2	346.2	346.2	346.3	346.3	346.3	346.4	346.4
346.5	346.6	346.7	346.8	346.9	347.0	347.0	347.1	347.2	347.2
347.2	347.2	347.2	347.2	347.1	347.1	347.0	347.0	346.9	346.9
346.8	346.8	346.7	346.7	346.6	346.6	346.5	346.5	346.5	346.4
346.4	346.4	346.3	346.3	346.2	346.2	346.1	346.1	346.0	346.0
345.9	345.8	345.7	345.7	345.6	345.5	345.4	345.3	345.2	345.1
345.1	345.0	344.9	344.9	344.8	344.8	344.7	344.7	344.6	344.6
344.5	344.5	344.4	344.4	344.4	344.3	344.3	344.3	344.3	344.2
344.2	344.2	344.2	344.2	344.1	344.1	344.1	344.1	344.1	344.1
344.1	344.1	344.1	344.1	344.0	344.0	344.0	344.0	344.0	344.0
344.0	344.0	344.0	344.0	344.0	344.0	344.0	344.0		

PEAK OUTFLOW IS 3551. AT TIME 16.83 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3551.	1898.	540.	540.	155556.
CMS	101.	54.	15.	15.	4405.
INCHES		9.29	10.58	10.58	10.58
MM		236.06	268.67	268.67	268.67
AC-FT		941.	1071.	1071.	1071.
THOUS CU M		1161.	1321.	1321.	1321.

SUMMARY OF DAM SAFETY ANALYSIS

.....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	343.60	343.90	345.90
	STORAGE	55.	60.	95.
	OUTFLOW	0.	0.	1076.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	347.20	1.30	121.	3551.	4.83	16.83	0.00
.40	346.91	1.01	115.	2837.	3.92	16.83	0.00
.30	346.56	.66	108.	2123.	2.67	16.83	0.00
.20	346.14	.24	100.	1398.	1.25	16.92	0.00
.10	345.32	0.00	85.	673.	0.00	17.00	0.00

APPENDIX 5

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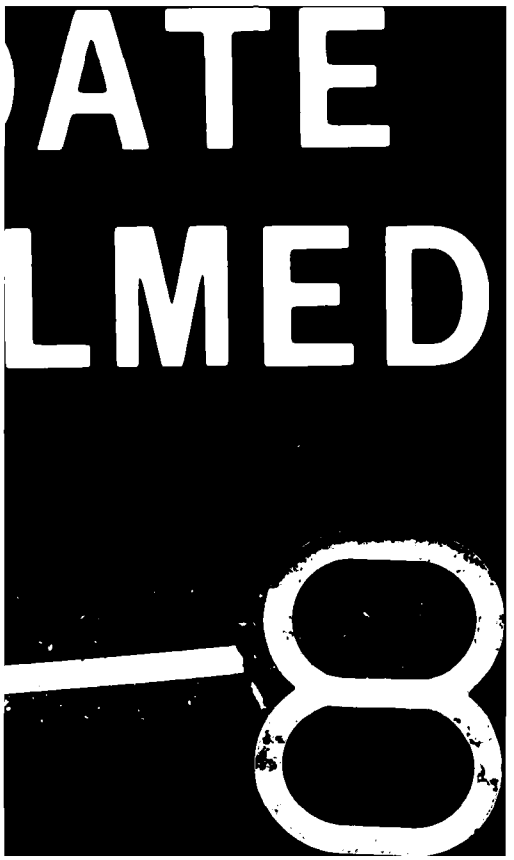
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